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MOBILE REST AND RELIEF FACILITIES FOR USE IN A CHEMICAL WARFARE ENVIRONMENT

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This report has been reviewed and is approved for publication.

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This technical paper outlines factors which need to be considered in the design, development, and operational use of Mobile Rest and Relief Facilities (MRRF). These facilities are intended primarily to provide support for military personnel operating in chemical warfare threat areas away from the support of fixed-base military installations. Besides providing a Toxic-Free Area (TFA), the MRRF must also provide the means for personnel to maintain operational effectiveness: food, water, replacement NBC clothing, washing and toilet facilities, lighting, communications equipment, and air conditioning. All of these support requirements need to be taken into account in the early stages of the MRRF concept definition and design. Failure to include these requirements in the development of an MRRF will limit its chemical warfare application.

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MOBILE REST AND RELIEF FACILITIES FOR USE IN A CHEMICAL WARFARE ENVIRONMENT

INTRODUCTION

This technical paper outlines some of the factors which need to be considered in the design, development, and operational use of Mobile Rest and Relief Facilities (MRRF). Such facilities are intended primarily for use by military personnel operating in chemical warfare (CW) threat areas away from the support of fixed-base military installations. For the purposes of this paper the assumption is made that the essential role of the MRRF is to provide personnel with collective protection facilities, with attendant rest and relief support, to permit the unabated continuation of military operations in the presence of an extended duration CW challenge. To fulfill this role the MRRF must provide, in addition to a toxic-free shelter, the means of maintaining the operational effectiveness of its user personnel. This shelter must, therefore, provide food and water supplies and the means of their replenishment and, where appropriate, the replacement of nuclear, biological and chemical (NBC) clothing. Washing, shaving, and toilet facilities will be required, together with adequate lighting, air conditioning of the rest area to cater for climatic extremes and means of intercommunication. These mentioned support requirements and their implications are important and should be taken into account in the early stages of concept and design definition of any form of MRRF. Failure to implement the requirement for these vital elements in the collective protection "system" as a whole is likely to result in the development of expensive equipment having a very limited chemical-warfare role application as toxic-free refuges for a limited number of "non-operational" personnel.

Mobile Rest and Relief Facilities essentially must provide a toxic-free shelter for personnel and the means to permit personnel transfer from the outside contaminated environment to the toxic-free shelter area without personal hazard or the transfer of contaminant in any form to the toxic-free area. Extensive work in the chemical safety proving of facility configuration and personnel entry and exit procedures for the fixed-base collective protection facilities indicates that there is little or no scope for any major changes in facility basic layout, or NBC operating procedures, when considering the MRRF. Although the facilities may be of significantly reduced scale, the basic Liquid Hazard Area (LHA), Vapor Hazard Area (VHA), Airlock(s), and Toxic-Free Area (TFA) approach of the fixed-base facilities will need to be applied to the MRRF. Their reduced scale, however, will allow a significant reduction in the NBC filtered airflow requirement for the MRRF in relation to the fixed-base facilities.

MOBILE REST AND RELIEF FACILITIES--USE

While flexibility of operational use must be considered in the overall requirements for the MRRF, certain operating parameters must be defined at an early stage of MRRF concept definition to provide guidance on detail design and, more particularly, on sizing. From the cost-effectiveness viewpoint, the facility should, over any defined period, provide rest and relief periods for as many personnel as is practicable, subject to facility sizing constraints.

At one extreme there is likely to be a minimum rest period, below which personnel operational effectiveness will not be acceptably maintained. At the other extreme the facility could provide for extended residence times to allow personnel a period of sleep. For a given size of facility, the choice of personnel residence time will have a marked effect upon the numbers which can be accommodated over a 24-h period. Table 1 gives the theoretical capability, in terms of number of personnel accommodated over a 24-h period, for a range of subject rest and relief times in the TFA of an MRRF. The values are based upon use of an 8-subject capacity MRRF and take into account realistic aircrew subject entry and exit processing times. These processing times are not included in the quoted rest and relief times. It should be noted that the theoretical values for number of (aircrew) personnel accommodated are unlikely to be achieved in practice as they assume very consistent and precise timing of events and the uninterrupted availability of personnel at rest and relief "shift" change times.

TABLE 1. THEORETICAL CAPABILITY FOR A RANGE OF SUBJECT REST AND RELIEF TIME IN THE TFA OF AN MRRF.

Rest Period Duration (h)	Subjects Accommodated (24 h)*
1	100
2	65
3	49
4	39
5	32
6	27
7	24
8	21
9	19
10	17

*Some subjects will not complete defined rest periods at 24-h point.

In relation to use of the MRRF there is, to the author's knowledge, no information from extended and realistic NBC trials to give any reliable indication of the duration or frequency of rest and relief periods required by personnel to maintain operational effectiveness when operating under an extended CW challenge. While the duration or frequency will no doubt vary for specific operational roles and climatic environments, it would be of value to know, for example, even under temperate conditions, the frequency with which individual helicopter aircrew, operating from field sites, need to use rest and relief facilities during consecutive 24-h periods of "NBC" operations. It would be of further value to know, in the absence of personal, chemically safe urination facilities, whether this factor would be predominant in dictating frequency of MRRF use. If it is, the possibility of reducing individual use of the MRRF by the development and provisioning of NBC compatible personal urination facilities should be considered.

It will be apparent that the sizing and the overall service scaling and cost of mobile rest and relief facilities are dependent to a large extent on the numbers of personnel to be catered to and on the intended mode of MRRF use. The mode of use of the MRRF could also influence the required scaling of NBC garments if their replacement is mandatory after each contaminated subject entry to the MRRF.

MOBILE REST AND RELIEF FACILITIES--LOGISTIC CONSIDERATIONS

By their very nature, the requirement for, and intended operational role of the mobile rest and relief facility demand a high degree of mobility to allow for rapid deployment to, from, and within CW threat areas. The means by which this requirement for mobility is met, whether by dedicated vehicles, air transport or other means, will impose logistic, cost, and procurement penalties which must be addressed at an early stage of MRRF concept evaluation. The need for electrical power supplies to support the MRRF filter-blower unit, air-conditioner unit, lighting and other subsystem requirements when operating at isolated field sites will dictate the provisioning of, and possibly the means of transportation for self-contained or integrated electrical power generators. Mention has been made elsewhere of the need for the periodic replenishment of stocks of water, food, and replacement NBC clothing in the TFA of the MRRF. The chemically safe means by which this support will be achieved and the logistic/procurement implications of this necessary support will require detailed attention at an early stage. The operational use of mobile rest and relief facilities will inevitably incur manpower penalties for its transport, setting up and closing down, and routine management when in the NBC operating mode. As an essential facility providing life-support and life-sustaining backup to operations in a CW environment, a strong case can be made for the establishment of a dedicated facility "manager" with responsibility for the operational management and chemical safety

aspects of the MRRF. In relation to this responsibility, it should perhaps be emphasized that during the clothing/equipment doffing and donning procedures associated with entry to and exit from the MRRF, personnel potentially will be at greater risk from exposure to and contact from CW agent contamination than when operating in the fully protected state in the field.

MOBILE REST AND RELIEF FACILITIES--DESIGN CONCEPT CONSIDERATIONS

For the purposes of this paper, consideration of MRRF design concepts is restricted to those approaches which provide self-contained facilities which can be operated in isolation from other buildings, structures, and domestic support services. Concepts which involve the use of flexible and inflatable liners to convert existing buildings/rooms into CW-agent-proof refuges, with which portable/transportable airlock and contamination control area sections could be integrated, are therefore, outside the scope of this paper.

Two basic forms of mobile rest and relief facility currently envisaged are:

(1) Flexible, proofed fabric, inflatable structures incorporating discrete areas to serve as the TFA, entry/exit airlock and VHA, and having an adjacent but external LHA.

(2) Rigid "cabin" type structures in which the TFA, entry/exit airlock and VHA are contained within the rigid structure, and the LHA may be provided by an attached and erectable flexible fabric penthouse.

Concepts of use of the inflatable form of structure have included its installation beneath conventional canvas tentage and also its erection inside existing buildings. Concepts of use of the rigid cabin form of structure have included its use as a free-standing structure, mounted on the back of a flatbed truck, and flatbed trailer mounted. Compatibility of design, sizing, and weight with the requirements for airlifting (C130 Cargo plane, Chinook helicopter underslung load) has also been a consideration.

There is a requirement, with both of these basic approaches, for a continuous supply of NBC filtered air to sequentially flush the TFA, airlock and VHA.

In theory, with careful design attention, both the flexible, inflatable structure approach and the rigid cabin approach are potentially capable of

meeting the basic chemical protection requirements for mobile rest and relief facilities. Many other factors, however, need to be considered in attempting to evaluate the relative merits of the two approaches. Some of these factors are listed next, together with comment on the "compliance potential" of each of the two approaches.

Low Cost Requirement

Both types of facilities require NBC air-filtration unit(s), air-conditioning unit, electrical power generator(s), TFA, VHA and LHA furnishing and lighting. The basic cabin cost with integral airlock and internal partitioning is likely to be between 3 and 4 times the cost of the inflatable structure and its protective tentage. Each approach will require a dedicated vehicle although a smaller vehicle should be required for stowage and transport of the inflatable MRRF.

Durability

To justify initial costs, the MRRF should have a storage/periodic training use life of at least 10 years and a guaranteed CW protective performance whenever it is deployed. These requirements should be readily achievable with the cabin type of MRRF. With the inflatable form of MRRF where CW performance is to a large extent dependent upon the integrity of a proofed fabric membrane and where transportation, erection, dismantling, and packing will involve extensive manhandling and exposure, there must be some reservations regarding the life-expectancy and performance guarantee.

Liquid Chemical Agent Penetration of the Facility

The rigid construction of the cabin-type MRRF readily lends itself to metallic skin, braced cavity wall fabrication, and with appropriate sealing should provide adequate protection against liquid chemical agent penetration of the vital TFA, VHA, and airlock sections. Absence of liquid chemical agent penetration of the fabric of the inflatable form of MRRF can only be guaranteed if the inflatable structure is protected by external coverage such as conventional tentage, an existing building, or by other means. During operating-site moves which involve the abandonment of chemically contaminated sites the inflatable facility dismantling, packing, and transport stowage procedures may be difficult to achieve without transfer of liquid agent contamination to the inflatable structure fabric.

Installation of Support Services in the Toxic-Free Area

The need for certain support services such as water, food and food-heating means, toilet and washing facilities, etc. in the TFA of mobile rest and relief facilities has been outlined. With the rigid cabin approach to the MRRF these basic support features and limited storage space for consumable items can be built in as permanent features. This built-in approach cannot readily be applied to the inflatable form of MRRF primarily because of site-move, "packaging," and transportation problems. Clean-site operations would, nevertheless, allow the removal of all such services/equipment from the MRRF TFA to facilitate "packaging" of the inflatable MRRF, and would also allow equipment reinstallation after a site move. However, with the inflatable MRRF, arrival at or departure from a chemically contaminated site would introduce major contamination control problems associated with the initial installation of the services/equipment in the TFA and with its subsequent removal from the TFA for a site move.

Control of the Protective Environment of the Facility

The chemical safety of the MRRF and of the associated personnel NBC ensemble doffing and donning procedures depends to a large extent upon close control of the protective environment of the TFA, airlock(s), and VHA of the facility. In this respect the volume flow, velocity, and distribution of the NBC filtered air throughout the facility, and the associated pressure differentials between the discrete areas, require control within defined limits. Such control is more readily achievable in the cabin approach to the MRRF where the basic rigid structure allows the use of conventional sealing of the airlock and entry/exit doors, allows the use of rigid ducting to facilitate air distribution, and provides a greater guarantee of basic structure leak tightness. In the emergency event of failure of the NBC filter-blower unit, the cabin-based MRRF can more readily and more reliably revert to a temporary "closed down" mode with the TFA and its inhabitants isolated from the outside environment.

On-Site Facility Preparation Time Arrival and Departure

The assumption is made that on arrival at a designated operations site the MRRF will be required to be operational in the shortest possible time and with the expenditure of minimal effort and manpower. It is also assumed these criteria will apply in the case of facility close-down for site abandonment.

In relation to the inflatable MRRF, on arrival at a site all components of the basic facility, external tentage if applicable, TFA, VHA, and LHA furnishings and equipment, support generator(s), NBC filter-

blower unit(s), and associated ducting will be required to be unloaded from the transport and manually assembled and erected to the operating state. The reverse will apply for facility close-down for site abandonment. Some of the implications of the unlikely event of initial CW contaminant presence at the site have been covered elsewhere in this paper and, in this event, the added measure of extensive purging of the facility TFA with filter-blower air would be necessary before its occupation by personnel.

In the case of the cabin-type MRRF, it is assumed that it would travel in the "closed-down" mode thus precluding or strictly limiting the transfer to its interior of any CW agent vapor met enroute or on site arrival. Assuming the filter-blower unit(s) would be an integral part of the cabin construction, coupling to the generator power source would permit clean air purging of the facility from an early stage while other tasks such as LHA penthouse deployment and installation of its furnishings were being undertaken. There is some evidence that the cabin-type MRRF can, by careful attention to this aspect of its design, be operational within 15 min of site arrival and, starting with an unoccupied TFA, be ready to leave the site 15 min after the site abandonment signal. These times are unlikely to be achieved consistently with the inflatable form of MRRF.

MISCELLANEOUS DESIGN AND OPERATIONAL CONSIDERATIONS

Control of Facility Thermal Environment

If global use of the MRRF is a requirement, the maintenance of a habitable environment in the toxic-free rest and relief area of the MRRF will only be possible under climatic extremes if an air-conditioning facility is provided. While it is possible to provide this facility as an integrated part of the NBC filter-blower unit, there are equipment bulk and electrical power requirement penalty considerations. In the cabin-type MRRF the use of double-skin-cavity walls should be exploited to provide thermal insulation between inner and outer skins. Although it would be difficult to apply effective thermal insulation to the inflatable form of MRRF, serious consideration would need to be given to the provision of insulative flooring in its TFA and VHA.

Nuclear, Biological, and Chemical Filter-Blower Units

The dependence of effective MRRF use on the availability of an uninterrupted flow of NBC filtered air from the associated filter-blower unit(s) suggests it may be prudent to use two independent units which together meet MRRF filtered airflow requirements and singly, in the event of one failure, would satisfy "temporary emergency" airflow

requirements. This approach would have a further advantage in allowing the field change of filter elements, one at a time, without the need for interruption of MRRF use. This arrangement implies that the isolation of filter outlet ducting immediately downstream of the basic filter elements, to maintain TFA integrity during a filter change, should be an early design consideration.

Electrical Power Generator

The maintenance of an uninterrupted source of electrical power to support the filter-blower unit(s), lighting, etc. requirements is equally essential to ensure the operational effectiveness of the MRRF. Consideration should be given to the provision of prime generator emergency back-up systems which provide battery-powered lighting and generated electric power solely to support filter-blower unit operation.

Facility Protection Monitoring

Some indication must be provided in the MRRF to allow its controller and/or occupants to verify the protective system is operating satisfactorily. Filter-blower airflow output can be visually displayed, in terms of pressure differential, from pressure tappings at discrete points in the unit. A visual display of pressure differentials between the TFA and outside environment and between the TFA and VHA is required. In the longer term, a chemical agent monitor, deployed in the TFA, could perhaps provide the ultimate verification of protective system performance.

Facility Intercommunications

Chemical safety considerations will dictate that personnel cannot move freely between the outside environment and the MRRF, or between MRRF areas, for purposes of communication. It is, therefore, essential that means of audio communication be provided between the outside environment and VHA and TFA, and between the VHA and TFA. A field telephone linkup between the TFA and outside environment is also operationally desirable.

Facility Camouflage

The field operations role of the MRRF will dictate a need for concealment by camouflage. The relatively high profile of the cabin-type MRRF, particularly if truck or trailer mounted, will require particular attention to camouflage needs.

Psychological Factors

Past studies which have involved military personnel in prolonged and repeated occupancy of the toxic-free rest and relief area of MRRF facilities have indicated that the provision of windows in the TFA is a significant morale booster in eliminating the "feeling of isolation" by allowing visual contact with the outside world.

From the rest and relief point of view, it is important to limit the transmission of noise from the operating filter-blower unit(s) and electrical power generator(s) to the TFA of the MRRF. With the cabin MRRF, where consideration may be given to mounting these support units on the cabin itself, design attention will need to be given to the location and possibly to the acoustic "isolation" of the noise generators. There is, however, an overriding operational need for the limitation of noise level from the MRRF.

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